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INTERMOUNTAIN INFILTROMETER

by

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CONTENTS

	Page
Introduction.	1
Description	2
Field installation	4
Calibration	15
Field operation	18
Laboratory procedure.	22
Related measurements.	25
Construction specifications	25
Literature cited.	40

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INTRODUCTION

Numerous kinds of infiltrometers have been developed in recent years for obtaining information about the capacity of watershed lands to take in water at the soil surface. Some, such as the tube or closed ring type (1, 5, 6, 11),1/ provide information only on infiltration and percolation rates. Others have devices for collecting and measuring surface runoff and eroded soil (2, 3, 7, 9, 10, 12, 13). The latter are especially well adapted for studying storm runoff and erosion control problems in which rainfall impact is an important factor. For studying such problems on the watershed lands of the Intermountain region, experience has indicated that an infiltrometer should embody the following features:

1. Sufficient lightness in weight for easy portability by two men over steep topography.

2. Sufficient plot size to encompass a representative sample of the interspersed vegetation, litter, and bare soil commonly found on Intermountain range lands.

3. Provision for quickly making applicator nozzle adjustments to obtain uniform distribution of rainfall over the plot.

4. Provision for applying artificial rainfall at rates up to 6 inches per hour and for changing rainfall rates during a test when it is desired to simulate the variable rates normally expected during torrential rains.

An infiltrometer to meet these requirements was developed at the Intermountain Forest and Range Experiment Station in 1947, and has since been used at various locations in Idaho and Utah. This apparatus is herein described. Suggestions are included regarding its field installation, calibration and operation, and the laboratory procedures and related measurements that are usually involved. An itemization of all parts of each of the several units and estimates of the cost of each unit are also given as a guide for those who may wish to construct the apparatus.

1/ Numbers in parentheses refer to Literature Cited, page 40 .

DESCRIPTION

The Intermountain type-F infiltrometer is a portable set of apparatus for applying artificial rainfall at either constant or variable rates up to 6 inches per hour on a sloping area about 9 x 9 feet in size, and for collecting and measuring resultant surface runoff and eroded soil from three 2- x 6-foot plots within the wetted area. Infiltration rates can be determined from the difference between rates of applied rainfall and runoff. The apparatus consists of ten units.

Water Supply.--This unit conveys water from a supply source to storage tanks in the vicinity of test-plot sites. It consists of a rotary high-pressure pump, 1,500 feet of 1½-inch linen discharge hose, two aluminum storage tanks having a combined capacity of 1,000 gallons, and 800 feet of 3/4-inch plastic gravity hose. If test sites are more than about one-fourth mile from a stream, lake, or other source of water, the unit should include a 1,000-gallon tank mounted on a 1½-ton truck. If small or unclear streams are to be used as the water supply, the unit should also include a supply tank of about 300 gallons capacity, which can be installed in or adjacent to the stream as a reservoir and sediment trap.

Pressure Circulation.--This unit conveys water at equal and proper pressure from an operating reservoir to each nozzle of a rainfall applicator unit. Principal items of equipment are an aluminum or galvanized operating reservoir of about 10 gallons capacity; a high-pressure rotary pump equipped with about 20 feet of 1-inch high pressure rubber discharge hose; a cylindical aluminum pressure tank of about 30 gallons capacity equipped with a pressure gage, a control valve, a bypass valve, a relief valve, and 14 tank valves; fourteen 3/8-inch plastic discharge hoses connecting these tank valves to the rainfall applicator nozzles; and a 3/4-inch plastic bypass hose to return excess water from the pressure tank to the operating reservoir.

Plot.--This unit includes a watertight frame of fixed dimensions for inclosing three 2- x 6-foot plots, to which simulated rainfall is applied, and from which runoff water and sediment are discharged. It consists of six steel cutoff walls, each 6 x 72 inches in size; a runoff spillway assembly consisting of three separate spillways, each 2 feet wide and welded together in a unit that attaches to the lower plot cutoff wall; a spring steel plot wall driver slightly under 6 feet in length, which is slotted to fit over the plot walls and prevent battering their edges during installation; and either an 8- or a 12-pound sledge hammer for driving the cutoff walls into the ground.

Windbreaker Tent.--This unit is used to protect the rainfall applicator unit and plots from wind disturbance during tests, in order to facilitate obtaining a uniform rainfall pattern over the plots and rain gages. The main parts of this unit are a tubular aluminum framework of four extendable legs and eight connecting crosspieces, a lightweight canvas tent cover that fits over the frame, and eight mooring stakes and guy ropes.

Runoff and Sediment Collection.--This unit provides for obtaining periodic samples of water and sediment, as well as a total catch of all water and sediment discharged from plots during a test period. It consists of three collector troughs with lids, three sets of three 10-gallon milk cans with lids for catching total discharge, about 6 dozen quart jars with lids for collecting periodic samples of discharge, and a stopwatch graduated in seconds for timing sampling periods.

Rainfall Collection and Measurement.--This unit provides for obtaining a periodic and total measure of rainfall during an infiltrometer test period. It consists of two precision-made trough gages 6 feet long, 1.8 inches wide, and 3.0 inches deep that mount on the outside plot walls; two collector tubes--one from each gage--which are joined into a single tube that carried rainfall to a rainfall measuring can equipped with a staff gage.

Rainfall Applicator.--This unit provides a rigid and easily adjustable support for mounting the rainfall nozzles accurately in relation to the test plots to produce a uniform rainfall pattern of prescribed intensity. This unit consists of two adjustable nozzle racks of aluminum channel construction, two batteries of 7 F-type nozzles mounted on the racks with movable ball-and-socket fittings, and a precision-made nozzle adjusting level.

Runoff and Sediment Measurement.--This unit is used to separate runoff water and sediment discharged from the infiltrometer plots and to measure the amount of each. Equipment includes three sets of three 10-gallon milk cans; three sets of three galvanized filter funnels; filter papers; four lucite graduates of 100, 250, 500, and 1,000 cubic centimeters in size; a 200-pound capacity platform scale; a 2,000-gram capacity triple beam balance; and, if electrical power is available, a soil oven. This equipment is kept at a work center or field camp where the runoff water and sediment from total plot discharges and from samples can be separated and measured under cover.

Accessory Equipment.--This unit includes a tool kit, spare parts, and other items of equipment needed in the calibration, installation, and operation of the infiltrometer.

Transport.--This unit consists of either one 1½-ton capacity stakeside truck or two 3/4-ton capacity stakeside trucks for transporting the unit to the field. A second 1½-ton capacity truck, equipped with a 1,000-gallon water tank, may be needed where it is desired to test infiltrometer sites beyond feasible pumping distance.

FIELD INSTALLATION

Experience with the infiltrometer has shown the following sequence, with two men working as a team, to be the most efficient for setting up the apparatus for field operation.

Water Supply.--This unit should be installed first in order to provide a supply of water for cleaning other units before they are set up, and to make certain the test plot sites are within reach of a water supply source.

The pump should be installed on a plank base near the supply tank and leveled to avoid vibration and creep (fig. 1). The suction hose intake, equipped with a strainer, should be kept at least 6 inches off the tank or stream bottom to minimize chances of sediment entering the pump. The discharge hose to the storage tanks should be laid out as straight as possible to avoid turns, which create friction. On steep slopes, it is generally necessary to tie the discharge hose couplings to stakes to prevent the hose line from sliding downhill when full of water.

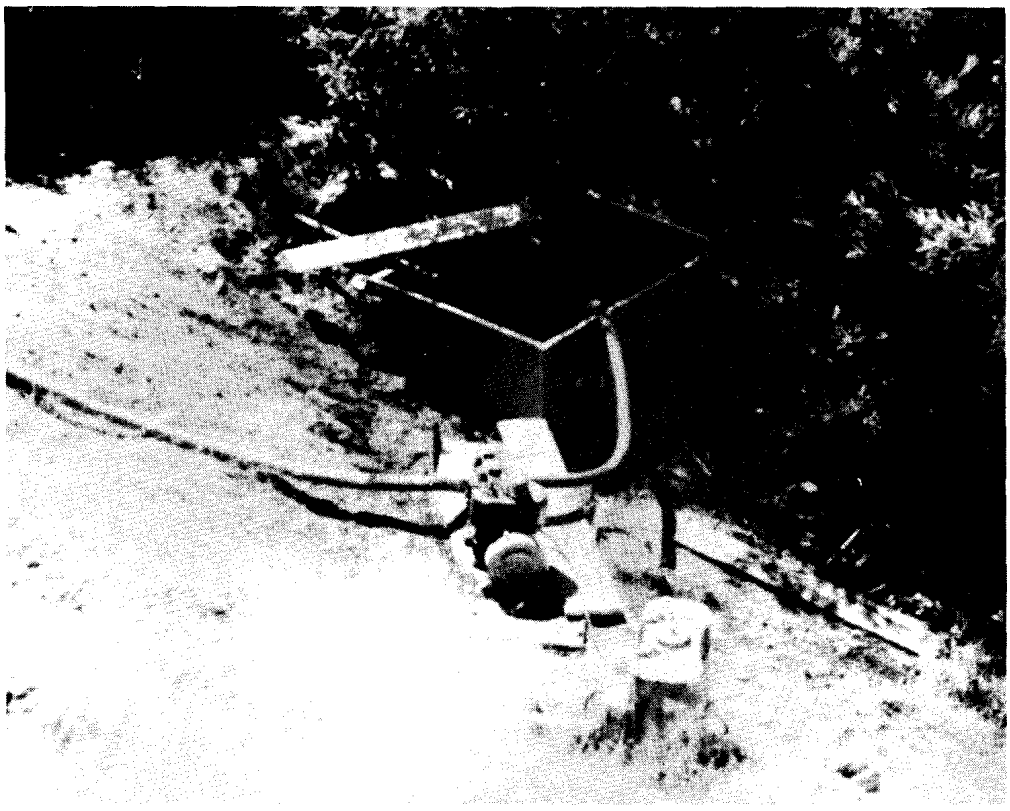


Figure 1.--Typical water development in small stream showing earthen dam, water supply pipes, open-top tank, suction hose, pump, and discharge hose.

The two water storage tanks can be rolled or carried by two men. They should be set on level ground above the areas to be tested (fig. 2). The tanks are joined by a Siamese coupling, which permits free flow of water between them and maintenance of a common water level in both when filling or draining.

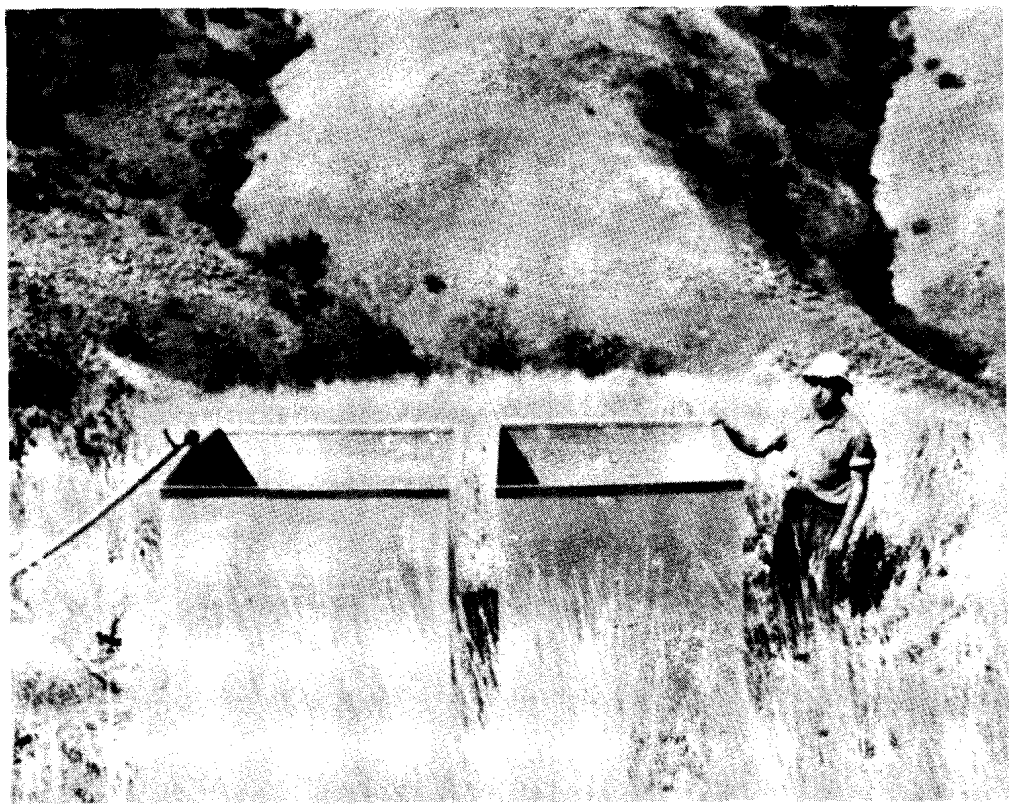


Figure 2.--Water storage tanks on ridge above stream source. In this instance water was pumped from the ravine in background over a 350-foot vertical lift to the tanks through 800 feet of 1½-inch linen hose.

The gravity hose is then attached to the Siamese coupling and laid out down hill to the 10-gallon operating reservoir near the test plots. The flow of water through the gravity line is controlled at the storage tanks by a valve in the Siamese coupling and at the lower end of the hose by a gate valve (fig. 3).

Pressure Circulation.--As soon as water is available through the supply unit, the pressure circulation unit should be installed at the test site. The operating reservoir should be located about 20 feet from the proposed test plot. Though only 10 gallons in capacity, this small operating reservoir provides sufficient capacity, by using the gate valve on the gravity hose, to regulate inflow from the storage tanks at the same rate as consumption by the infiltrometer.

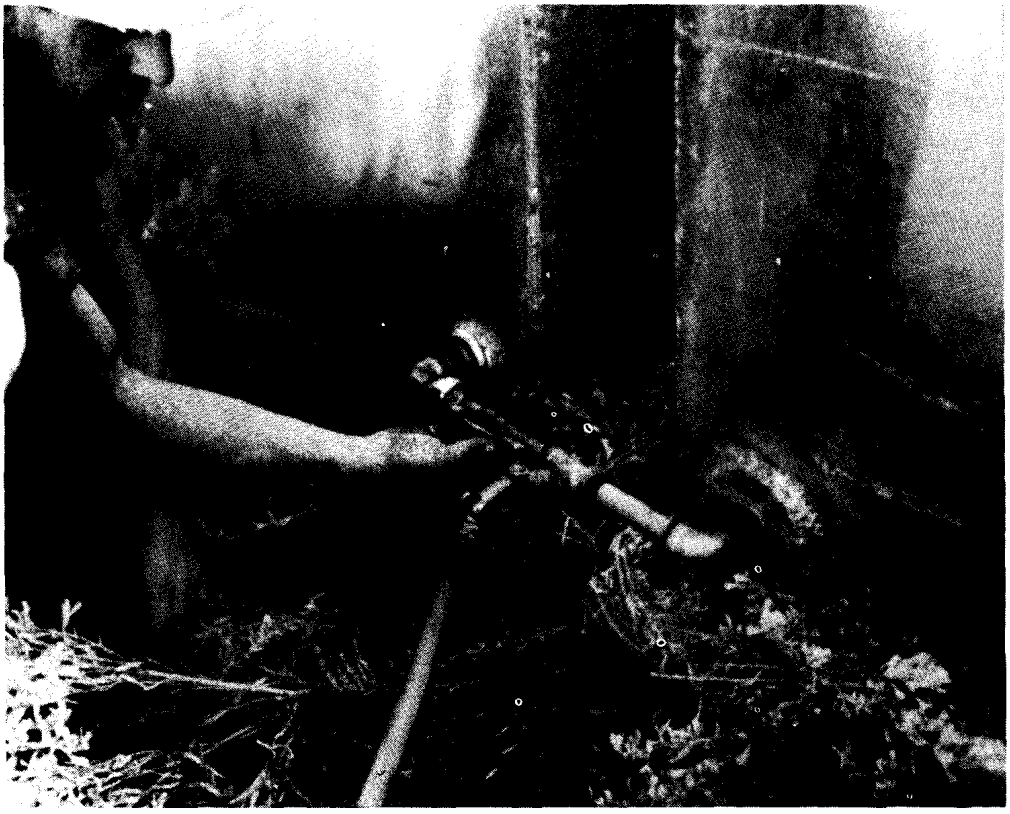


Figure 3.--Siamese coupling between storage tanks showing valve and plastic gravity hose.

The pump should be set up about 15 feet from the test plot on a level plank base. It may be found desirable to set the pump on a waterproof tarpaulin so as to divert exhaust water away from the base of the pump. The suction line from the pump, equipped with a strainer, is inserted in the operating reservoir. The pressure hose from the discharge side of the pump to the pressure control tank is connected by means of two quick snap-on couplings (fig. 4).

The pressure control tank should be located about 5 feet below and 5 feet to one side of the lower edge of the proposed test plot. A pressure gage is attached to the tank with a quick snap-on fitting. The bypass hose is coupled to a bypass valve on the tank and returned to the reservoir. This bypass line permits higher pressure in the line from the pump than is maintained in the tank and, hence, acts as a surge system to dampen pressure fluctuations in the tank. The pressure hoses from individual valves on the tank to the rainfall applicator nozzles are attached with quick snap-on couplings (fig. 5).

Figure 4.--Portion of pressure circulation unit showing the 10-gallon reservoir, suction hose, pump, and discharge hose.

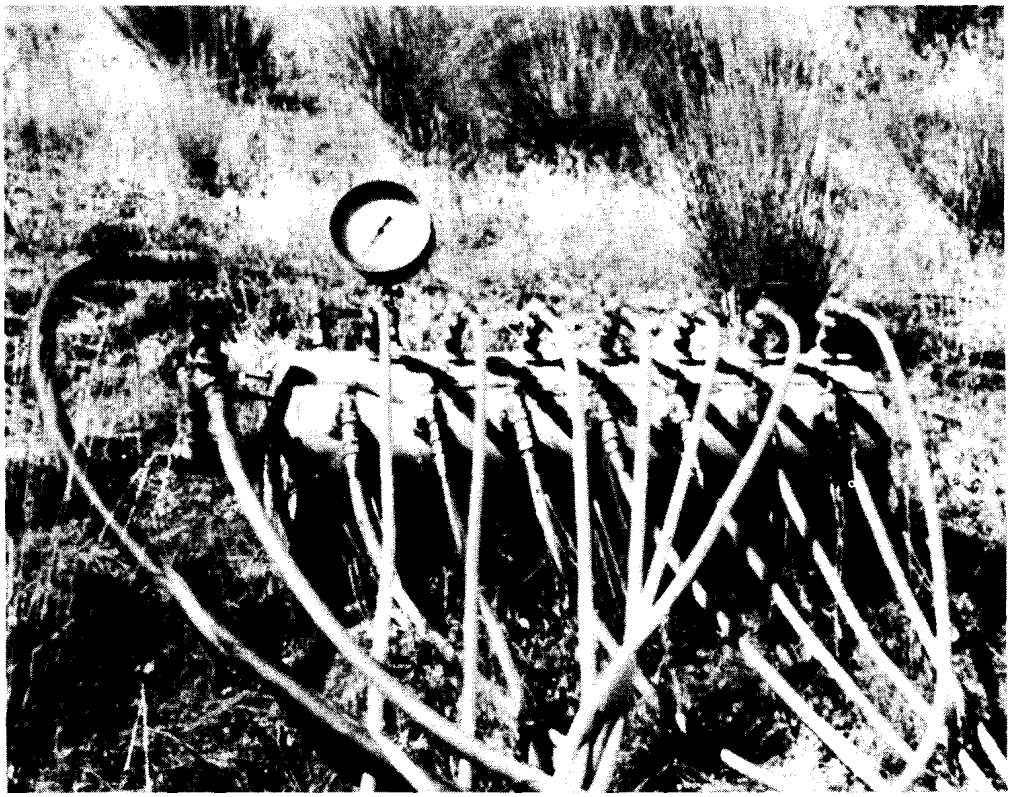


Figure 5.--Portion of pressure circulation unit showing pressure line from pump, pressure control valve, bypass valve, pressure control tank, relief valve, pressure gage, bypass hose, and 14 pressure lines to nozzles.

When this assembly has been completed, the pump can be started. However, before starting the pump, the bypass valve should be closed and the pressure control valve and top row of 7 tank valves opened. This permits escape of entrapped air in the tank as it fills. When the pressure tank is full, each nozzle pressure hose, in turn, should be thoroughly flushed out, being careful to insure that the pressure on the gage does not exceed 60 pounds per square inch.

Plot.--After determining the location of a test plot, the cutoff walls of the frame should be laid out on the ground in their relative positions just outside the plot boundaries (fig. 6). The lower cutoff wall is inserted first, one man holding the plot-wall driver on the wall, the other pounding it into place in the ground with a sledge hammer. As soon as the top edge of the cutoff wall is flush with the ground, the runoff sill is slipped over the wall and also tapped down carefully until it is flush with the ground. Next, the two outside walls are installed in the same manner as the lower wall, but for only half their depth or about 3 inches. The upper wall is then slipped into place with the

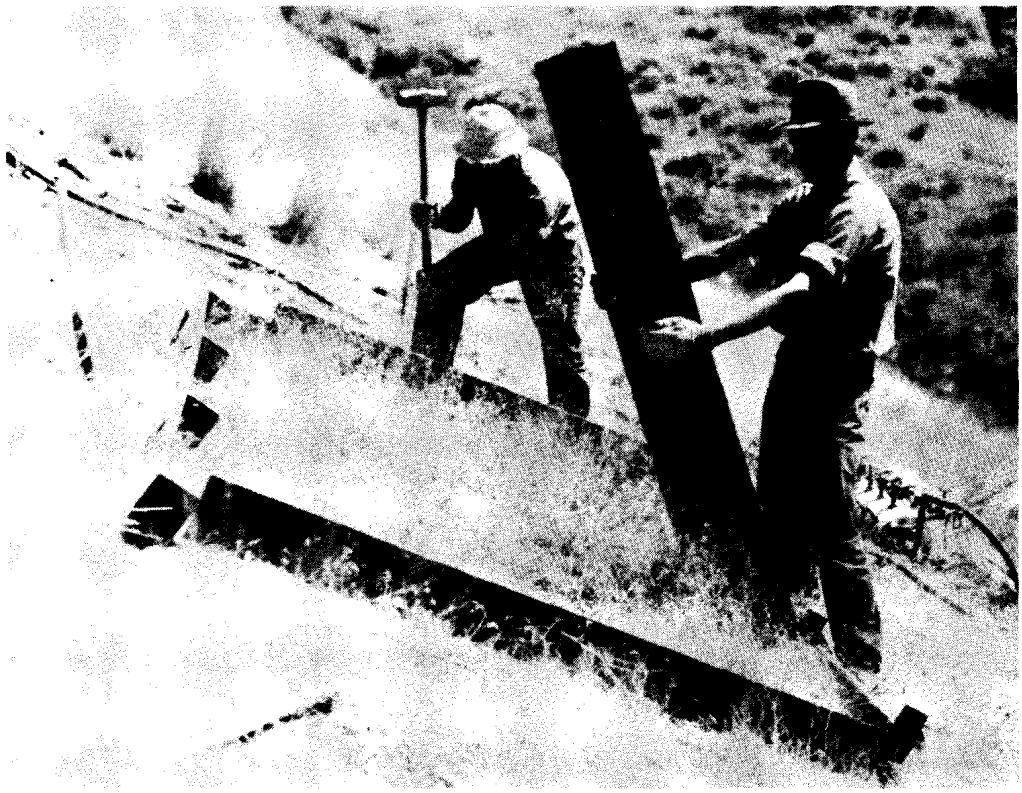


Figure 6.--Installing a plot unit on an annual weed site in Idaho. The plot-wall driver is being employed to protect the side wall in the background from damage by the sledge hammer.

split-plate corner frames fitting tightly over the upper ends of the side walls and is driven halfway into the ground. The two inside walls are fitted into the split-plate slots of the upper wall and over the flanges of the runoff sill and driven halfway into the ground.

After the plot frames are installed, about 2 inches of soil should be cleared out from under the lower side of the runoff spillways to permit fitting the runoff collector troughs in place (fig. 7).

Figure 7.--A plot spillway with soil cleared away to provide space for runoff collector trough. A portion of the collector trough on the adjacent plot can be seen at right.

It is desirable to have from four to six complete sets of plot frames. This will permit setting up several plots in advance of rainfall application; also, by moving only the rainfall applicator and tent, successive or repeated applications of water can be made without disturbing the test plots (fig. 8).

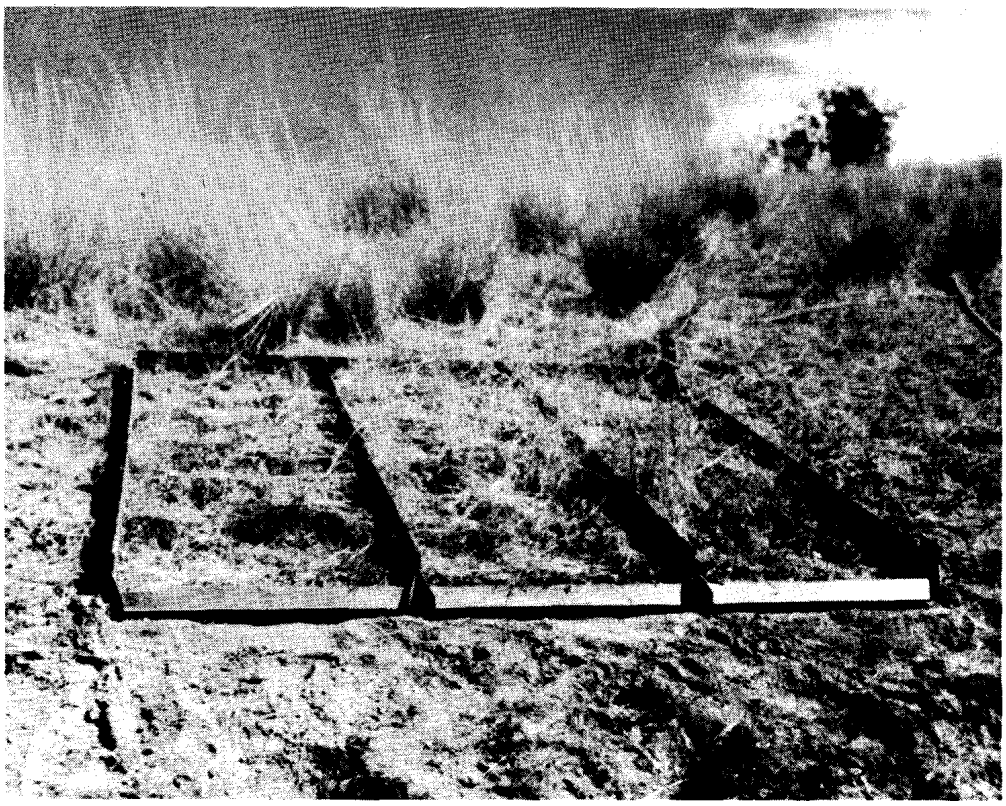


Figure 8.--Plot walls and runoff spillways installed on a triple plot. In this instance, the subplots were subjected to heavy, medium, and light artificial trampling disturbance.

Windbreaker Tent.--The tubular aluminum tent frames can be assembled most conveniently at a point just above the plots but not over them. The frame should be assembled with the legs telescoped to give minimum height of about 6 feet. In this position, all brackets can be reached and the wingnut fasteners tightened by hand.

The tent cover can then be worked on over the top of the assembled frame from the uphill side and oriented so the reinforced canvas corners fit the frame corners properly. The slit front of the cover, equipped with either a zipper or snaps for closing, should be open for this fitting.

The four extension legs are then extended to their full length of about 9 feet and locked in that position by tightening a lock wingnut. Canvas ties on the inside corners of the cover are tied to the legs about halfway up to reduce wind slap. In the extended position, two men can easily move the tent downhill to a position over the plots by grasping a lower horizontal crosspiece on each side. The tent is then positioned over the plots so that each side is equidistant from the plot side walls--about 2½ feet--and so the slit-front side of the tent is about 1 foot

downhill from the runoff sill at ground level (fig. 9). The guy ropes are then fastened snugly to aluminum stakes driven about 8 or 10 feet out from the corners and sides.

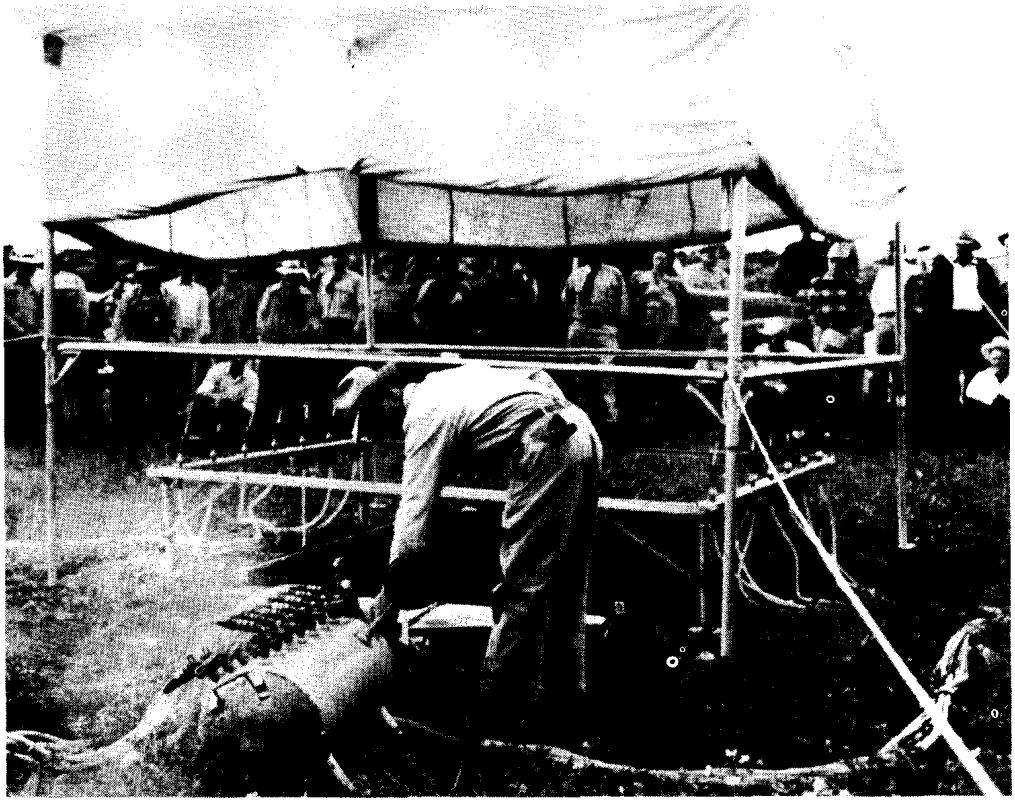


Figure 9--Demonstration setup of infiltrometer showing tent framework and cover. During normal tests, the cover is lowered for protection against wind disturbance.

The tent should be left moored in the lower position with the slit front and side windows closed when unattended to reduce chances of wind damage. The tent can be moved without taking it down, though this procedure is recommended only when test plots are within 100 feet or so from one another.

Runoff and Sediment Collection.--The runoff and sediment collection unit should be installed after the windbreaker tent is in place over the plots. Each of the three collector troughs has a lip on the straight upper edge. This lip fits under the runoff sill and the collector trough lid fits over both the trough and sill so its upper edge comes to the lower edge of the plot. A sliding extension on the upper edge of the lid permits this relationship between the upper edge of the lid and the lower boundary of the plot to be maintained regardless of slope steepness (fig. 10).

Figure 10.--Runoff collector troughs installed on spillways of plots showing extension on lids and collector cans below.

Three pits should be dug just below the collector trough spouts to accommodate the collector cans. These collector cans should be set so the aluminum collars on the trough spouts are outside of the can. This permits rainfall drip on the trough lids to drain off before reaching the collector cans.

Rainfall Collection and Measurement.--The trough rain gages should be hung on each of the outside plot walls by metal brackets (fig. 11). The gage position should be adjusted so the lower end of each is opposite the lower edge of the plots (fig. 7).

The collector tubes are then screwed onto the threaded fittings at the lower end of each gage and the other ends of the tubes are joined into a single tube that is inserted into the stilling well of a calibrated rainfall measuring can. The rainfall measuring can is leveled by setting the two bubbles of the nozzle adjusting level to zero, placing this instrument in the bottom of the can and adjusting the can to center the bubbles. With the can leveled, a porcelain staff gage, graduated in hundredths of a foot, is inserted into a bracket on the inside wall of the can (fig. 12).

Figure 11.--Trough rain gages showing metal brackets for attaching gages to plot walls.

Figure 12.--Rainfall measuring can showing collector tubes from gages and porcelain staff gage.

Rainfall Applicator.--The rainfall applicator unit is best assembled just below the rainfall collector can, then moved directly uphill through the slit-front opening of the tent cover, and into place over the plot. Assembly is accomplished by folding the legs out from the nozzle racks and joining the ends of the racks with spread bars fastened with wingnuts to form a rigid frame. The frame is then positioned over the plot so that:

1. The center lines of the nozzle racks are 18 inches outside of the nearest side plot wall.

2. The end nozzles on each rack are opposite the upper and lower plot walls, respectively.

3. The nozzle mouths are 30 inches above the plot surface. The pressure hoses from the circulation system are then fastened to the nozzle mounts under the racks. With the nozzles pointed away from the plots by swiveling them on their ball-and-socket bases, the circulation system is started and each nozzle flushed to insure that none is clogged. The nozzles are then set with the nozzle adjusting level, each at the proper angle as determined during calibration (fig. 13).

When the nozzles have been adjusted, the collector troughs, rain gages, and rainfall collector tubes should be flushed with water to prewet them and insure they are clean. The front of the tent cover should then be closed. The infiltrometer is then ready for operation.

Complete installation, as outlined, normally requires about 3 hours' work by two men after the water supply unit is in. It is desirable to locate as many test sites as possible within gravity line reach of the water supply storage tanks, in order to avoid moving the water supply unit more often than necessary. When operations permit testing of sites in close proximity, much of the equipment assembly can be moved intact. Under such conditions, changing from one site to another requires about 2 hours.

Figure 13.--One of the applicator nozzle racks showing hoses from pressure tank, flexible nozzle bases, type-F nozzles, and nozzle adjusting level. When setting the nozzle it is important to grasp the nozzle and not the level.

CALIBRATION

The infiltrometer must be calibrated prior to field use. This is necessary to determine the following relationships:

1. The angular setting of the nozzles in relation to the test plots to obtain uniform rainfall distribution over the plots.

2. The ratio of rainfall on the plots to rainfall on the trough gages.

3. The rainfall depth relationship between the trough gages and the rainfall collector can.

Calibration can be accomplished satisfactorily either indoors or outdoors. However, where facilities such as a concrete floor and drain are available, indoor calibration is generally simpler. For outdoor calibration, the windbreaker tent should be used.

Determining Angular Setting of Nozzles.--The first calibration procedure is to determine the proper setting of each nozzle to obtain uniform rainfall distribution at each rainfall rate. The process is one of trial and error and consists of the following steps:

1. Establish a network of 32 small rain gages (No. 2 tin cans are satisfactory) uniformly distributed eight to each subplot and four along the outer edge of each rain trough. Lay burlap or canvas on the plots to minimize splash into rain cans.

2. Set nozzles at a trial angle and record angle of each.

3. Make three 10-minute rainfall applications at 35 pounds water pressure. After each 10-minute application, measure and record volume of catch in each can. Compute and record rainfall rate for each can. If calibration is performed on a slope, the computed rates should be corrected for slope before being recorded. Determine and record the average rate of the three rainfall catches in each can; also of all cans. Determine the maximum average can variation from the average of all cans. This deviation should not exceed 10 percent.

4. Repeat the three 10-minute rainfall applications as described under 2 and 3 above, until a combination of nozzle angle settings is found that produces a rainfall pattern within the desired limits of variation.

The manner in which the calibration may be recorded and handled to determine pattern uniformity is shown in a sample Infiltrometer Calibration Test Form (fig. 14).

When a rainfall pattern of desired intensity and uniformity has been obtained, a record of the nozzle numbers, their angular settings, and the position they occupy on the nozzle racks should be made and carried in an appropriate notebook for field reference. Matching reference lines should also be etched on the nozzle base and the nozzle rack, to permit orienting the nozzle in the same position each time before it is leveled.

Determining Plot-Trough Gage Rainfall Ratio.--It is essential to know the precise relationship between the amount of rain falling on the plots and that falling on the troughs lying just outside the plots on either side. This relationship can be established from test runs by determining the ratio of the average rainfall rate in the plot gages to that in the trough gages. This ratio is called the trough gage correction factor. A sample computation is shown on the sample Infiltrometer Calibration Test Form.

INFILTROMETER CALIBRATION TEST RECORD

Date 6/24/51 Test No. 7 No. Runs 3 Time per Run 10 mins

Slope 45 % 24° 14' ° Slope Correction Factor (secant of slope angle) 1.10 .

Conversion Factors:

plot gage rainfall rate (in./hr.) = test vol. (cc) X $\frac{60}{\text{test time (min.)}}$ / cc/in.^{3} X area of gage (in.^{2}) = .05179 .

trough gage rainfall (in./hr.) = test vol.(cc) X $\frac{60}{\text{test time (min.)}}$ / cc/in.^{3} X area of gage (in.^{2}) = .00141 .

Nozzles: Left bank: No. 1-2-4-6-7 Right bank: No. 1-2-4-6-7 .
Angle 1° 3° 5° 3° 1° Angle 1° 3° 5° 3° -1° .

Test Rain Volume (cc)

Plot Gages

25	1	2	9	10	17	18	29
65	66	67	71	73	70	68	67
67	68	67	70	72	71	69	69
66	66	64	68	71	72	70	71
26	3	4	11	12	19	20	30
69	70	72	73	71	68	67	65
71	71	73	74	72	69	67	66
70	72	74	75	73	70	68	67
27	5	6	13	14	21	22	31
64	67	70	70	72	74	75	74
65	66	69	70	71	73	74	73
64	64	66	68	71	72	73	71
28	7	8	15	16	23	24	32
63	65	66	69	70	72	73	72
64	64	65	68	70	73	73	72
62	64	67	69	71	74	72	72

Trough Gages

2560
2550
2545
2552

Rainfall Intensity (in/hr) (corrected for slope)

Plot Gages

Run No.	25	1	2	9	10	17	18	29
1	3.70	3.76	3.82	4.04	4.16	3.99	3.87	3.82
2	3.82	3.87	3.82	3.99	4.10	4.04	3.93	3.93
3	3.76	3.76	3.65	3.87	4.04	4.10	3.99	4.04
Av.	3.76	3.80	3.76	3.96	4.10	4.04	3.93	3.93
	26	3	4	11	12	19	20	30
1	3.93	3.99	4.10	4.16	4.04	3.87	3.82	3.70
2	4.04	4.04	4.16	4.22	4.10	3.93	3.82	3.76
3	3.99	4.10	4.22	4.27	4.16	3.99	3.87	3.82
Av.	3.99	4.04	4.16	4.22	4.10	3.93	3.83	3.76
	27	5	6	13	14	21	22	31
1	3.65	3.82	3.99	3.99	4.10	4.22	4.27	4.22
2	3.70	3.76	3.93	3.99	4.04	4.16	4.22	4.16
3	3.65	3.65	3.76	3.87	4.04	4.10	4.16	4.04
Av.	3.66	3.74	3.89	3.95	4.06	4.16	4.22	4.14
	28	7	8	15	16	23	24	32
1	3.59	3.70	3.76	3.93	3.99	4.10	4.16	4.10
2	3.65	3.65	3.70	3.87	3.99	4.16	4.16	4.10
3	3.53	3.65	3.82	3.93	4.04	4.22	4.10	4.10
Av.	3.59	3.66	3.76	3.91	4.00	4.16	4.14	4.10

Trough Gages

1	3.97
2	3.96
3	3.95
Av.	3.96

Maximum variation from average of all gages (in./hr.) / Average rainfall rate of all plot gages (in./hr.) = .36 / 3.95 = 9.1% variation in rainfall over plots

Average rainfall rate of all plot gages (in./hr.) / Average rainfall rate on trough gages (in./hr.) = 3.95 / 3.96 = .9974 = trough gage correction factor

Figure 14.--Sample of infiltrometer calibration test record form.

The rainfall measured in the trough gages is multiplied by the correction factor to obtain plot rainfall. Ideally, this correction factor should be 1.0. If this factor varies from 1.0 to more than 5 percent, the distribution of rainfall over the plot should be rechecked and the distribution improved so as to bring the correction factor within 5 percent.

Determining Trough Gage --Collector Can Rainfall Relation.--To facilitate rapid determination of total rainfall in the trough gages at any time during a test, it is desirable to calibrate the rainfall collector can with reference to the trough gages. Knowing the intercepting area of the trough gages and the cross-sectional area of the collector can, this calibration is accomplished by relating a volume of water equivalent to a given depth on the trough gages to the depth created by this volume on a staff gage in the collector can. This process is repeated with successive increments of volume until the can is full, recording the depth each added increment creates on the staff gage.

The staff gage readings and trough gage depths are used to plot a curve from which trough gage depths for each 0.01 foot of staff gage depth can be read. These readings of trough gage depth are tabularized into a calibration table which should be carried in a field tatum or notebook.

It is recommended that a collector can 11.73 inches in diameter be used with trough gages having an interception area of 259.2 square inches. This provides an interval of 0.02 foot in the staff gage for every 0.1 inch of rainfall in the trough gages.

FIELD OPERATION

With the infiltrometer calibrated and installed on a plot site, a test may be begun when a supply of water sufficient for the duration of test desired has been accumulated in the storage tanks. This infiltrometer has been found to consume about 2.5 gallons of water per minute per inch of rainfall applied (table 1). The rate of consumption could be reduced substantially by remodeling the exhaust-cooling system of the pump so as to vent coolant water back into the reservoir (3) instead of wasting it out the exhaust.

Table 1.--Gallons of water required for infiltrometer tests of various rainfall durations and rates

Test time (minutes)	Rainfall rates					
	1	2	3	4	5	6
	Inches/hour					
10	25	50	75	100	125	150
20	50	100	150	200	250	300
30	75	150	225	300	375	450
60	150	300	450	600	750	900

A regular test run involves four operating procedures: (1) adjusting the pressure system; (2) measuring rainfall; (3) observing the plot surfaces; and (4) sampling and collecting runoff and sediment. It has been found convenient to have one operator devote his attention to the first two activities and, in addition, keep a record of rainfall and of elapsed time of the test, and to have a second operator handle the latter two activities and record duration of sampling periods.

Adjusting the Pressure System.--The pump is started after the bypass and pressure control valves are opened and all nozzle valves on the pressure tank are closed. As soon as the pump is running smoothly, the pressure gage should be brought to about 45 pounds pressure by adjusting the bypass and pressure control valves. At time zero--preferably at the beginning of an even minute--the valves to those nozzles to be employed are opened quickly and the pressure readjusted to 35 pounds. The gate valve on the gravity feed line is then quickly opened and adjusted to maintain a constant level in the 10-gallon operating reservoir.

After these initial adjustments, any pressure differential from 35 pounds can quickly be corrected with the pressure control valve. Numerous tests have been made without having to adjust pressure after the initial setting.

At the end of the test, the nozzle valves are quickly closed and the pump and gravity-feed gate valve turned off. The gravity feed line may be shut off about 40 seconds to a minute before termination of the test so the operating reservoir is nearly drained by the time the test ends.

Measuring Rainfall.--The rainfall rate is determined by measuring the depth of rain water on the staff gage in the rain collector can at periodic intervals, preferably every 5 minutes. The staff-gage reading in hundredths of a foot is recorded on an appropriate Infiltrometer Field Test Record Form (fig. 15). The difference between successive staff-gage readings is entered in the rainfall collector can calibration table

Study Title _____

Plot No. 76

INFILTROMETER FIELD TEST RECORD

Date 9/10/51

TIME		PRECIPITATION				SAMPLE DISCHARGE					TOTAL DISCHARGE						
			Depth		Inter-val rate				Rate		Weight					Water	
Elapsed	Interval	Staff gage	Interval amount			Time	Water volume	Soil weight	Run-off	Ero-sion	Discharge plus can	Can	Discharge	Soil	Water	Volume	Depth
(min)	(min)	(ft)	(ft)	(in)	(in./hr)	(sec)	(cc)	(gms)	(in./hr)	(lb/A/hr)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	($in.^3$)	(in)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Uncorrected for slope																	
0		0.00	—	—	—	—	—	—	—	—							
5	5	0.04	.04	.2	2.40	—	—	—	—	—							
10	5	0.10	.06	.3	3.60	10	4	.1	.0510	285.6							
15	5	0.16	.06	.3	3.60	10	11	.2	.1400	571.2							
20	5	0.22	.06	.3	3.60	10	20	.3	.2540	858.0							
25	5	0.28	.06	.3	3.60	10	30	.4	.3820	1143.6							
30	5	0.34	.06	.3	3.60	10	35	.6	.4450	1714.8							
31	1	0.36	.02	.1	1.20												
Average or total				1.80	3.60				.2120	762.2	29.75	23.25	6.50	.1036	6.40	177.1	.1025
Corrected for slope																	
0		0.0	—	—	—	—	—	—	—	—							
5	5	.044	.044	.22	2.64	—	—	—	—	—							
10	5	.110	.066	.33	3.96	10	44	.18	.056	314.2							
15	5	.176	.066	.33	3.96	10	12.1	.22	.154	628.3							
20	5	.242	.066	.33	3.96	10	22.0	.33	.279	943.8							
25	5	.308	.066	.33	3.96	10	33.0	.44	.420	1258.0							
30	5	.374	.066	.33	3.96	10	38.5	.66	.490	1886.3							
31	1	.396	.022	.11	1.32												
Average or total				1.98	3.96				.2332	932.4				.1140			.1128

Time rainfall began 0

Time rainfall ended 0 + 30'

Time overland flow began 0 + 2'

Time overland flow ended 0 + 30'

Time runoff began 0 + 5

Time runoff ended 0 + 31'

Total depth of water runoff (in.) .1128 / Total depth of rainfall (in.) 1.98 = 5.70 % runoff

Total soil weight (lbs.) .1140 X 3,630 = 414 lbs./acre erosion

Slope

Percent 45

Degree 24°14'

Correction factor 1.10

Remarks _____

Figure 15.--Sample of infiltrometer field test record form.

to determine inches depth of rainfall on the trough gages during the preceding 5-minute period. This depth is converted to rate in inches per hour, and both the depth and rate are recorded on the data form. Total rainfall at any time during a test is obtained merely by entering the staff-gage reading at that time in the calibration table.

Observing the Plots.--Observing what is taking place on the plots during a test is one of the most important activities. Each nozzle, when turned on, should be visually checked to see if it is clogged. If clogged, the operator manning the pressure system is notified and all nozzles are turned off until the stoppage is cleared and the nozzle reset. Whether a test should be resumed on the same plot following correction of a stoppage will depend upon the importance of plot wetness as a variable in the study.

The operator should watch the plots for the beginning and ending of depression storage, overland flow, soil movement, and runoff over the plot spillways. The time of these occurrences should be recorded on the Field Form. Such irregularities as leakage under plot cutoff walls, down rodent holes, etc., should also be recorded. It may also be desirable to make other observations. Among these, may be a record of the number and depth of rills or gullies, the depth of rainfall penetration under plants and litter and under bare soil, and changes in the surface features of the plot, such as development of erosion pavement, litter dams, etc. These items can be recorded on the back of the Field Form.

Sampling and Collecting Runoff and Erosion.--Different procedures should be used for collecting the plot discharge, depending upon the purpose of the test. When the objective is to determine the total amount of runoff and sediment produced by a given test rainstorm, the procedure simply involves catching all of the plot discharge in one or more collector cans for subsequent weighing and filtering. When the objective is to determine rates of runoff, sediment production, and infiltration, it is necessary to obtain rates of discharge during the test run.

A sampling procedure is recommended for the latter purpose in which 10-second samples of the discharge are caught in small jars at 5-minute intervals during the run. As each sample is obtained, it is capped and numbered and the sampling time, recorded by stopwatch, entered on the Field Form. The length of the sampling time and the sampling interval can be varied as conditions warrant. For example, shorter time samples at more frequent intervals are usually necessary for determining the slope of the depletion runoff after rainfall has stopped.

When information is desired about the infiltration capacity of a site, rainfall should be applied at a constant rate that is at least 1 inch per hour greater than the maximum rate of runoff. Infiltration values can be obtained from tests made on dry plots. However, it is generally desirable to obtain such data from plots that have been prewet.

LABORATORY PROCEDURES

The samples and/or total discharges collected from the field tests should be transported to a work center or field camp for separation and measurement of runoff water and sediment (fig. 16). Where a power supply is available, the samples can be handled by evaporating the water in a soil oven. Separation of total runoff from sediment is best accomplished by filtering.

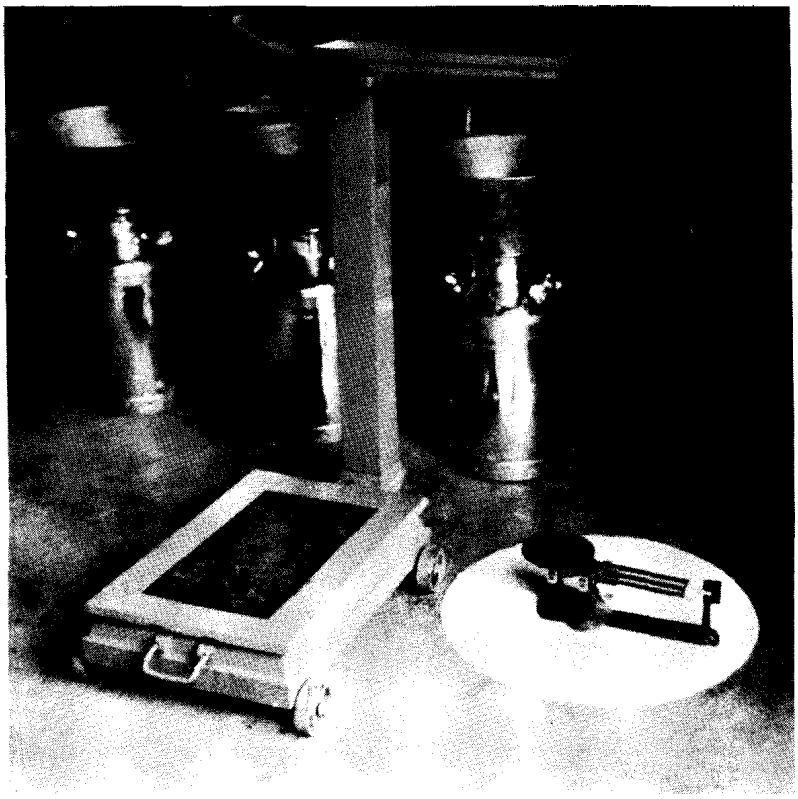


Figure 16.--Weighing cans, filter funnels, and platform scales for handling total discharge measurements and triple-beam balance for weighing discharge rate samples.

Samples.--When samples are involved, they should be weighed to the nearest tenth of a gram, filtered, and the sediment air-dried for 48 hours. The sediment is then weighed and the volume of water in cubic centimeters determined by subtracting sediment weight from total sample weight. Both the volume of water and the weight of sediment are recorded opposite the proper sample period on the Field Test Form. Each is then extended from the sampling time to computed amounts discharged during the 5-minute period in which they were taken and converted, respectively, to runoff in inches per hour and erosion in pounds per acre per hour. These values are recorded on the Field Form under "Sample discharge rate" and are used to compute an average runoff and erosion rate during the test period.

The infiltration rate for each 5-minute period is obtained by subtracting the runoff rate from the rainfall rate for each corresponding period.

Total Plot Discharge.--When total plot discharges have been collected, the numbered can containing water and sediment are weighed to the nearest quarter of a pound to obtain total discharge weights. The discharge is filtered and the sediment air-dried for 48 hours. The sediment is weighed in grams, converted to pounds, and the weight subtracted from total weight of discharge to obtain weight of runoff water. The pound values of both are recorded on the Field Form under "Total discharge." The weight of water is converted to volume and then to inches depth over the plot.

All values recorded on the Field Form, including precipitation depth and rate, sample runoff and erosion amounts, and total runoff and erosion are corrected for variation in slope gradient. This can be done by multiplying each value by an appropriate slope correction factor. This correction factor, the secant of the slope angle, reduces all measurements to a common horizontal base. The corrected values are recorded in the appropriate columns on the lower half of the Field Form.

The data given on the sample Field Form were obtained from a plot on which runoff and erosion were measured both by sample and total yield procedures. The percent of runoff and pounds per acre of erosion shown in the lower right hand corner of the form were computed from total yield measurements. They show that runoff was 0.1128 inch or 5.70 percent of the rainfall during the 30-minute test period, and 0.1140 pound of soil or 414.0 pounds per acre were eroded from the plot.

The sample data show that the average runoff rate was 0.2332 inch per hour or 0.1166 inch during the 30-minute test. This amount is equivalent to 5.89 percent runoff or very nearly the same as the total runoff yield actually obtained. The sample data also show that the average rate of soil erosion was 838.4 pounds per acre per hour or 419.2 pounds per acre during the test, which was nearly the same as the total erosion obtained. Frequent similar checks of amounts of runoff and erosion obtained both by sampling and total catch indicate that, with carefully collected and accurately timed samples, the error involved in sampling can generally be held within about 5 percent.

RELATED MEASUREMENTS

Measurements of runoff and sediment production from infiltrometer plots are not especially meaningful unless they can be related to the site characteristics that account for them. These may include subsurface features such as soil pore space (4), bulk density, texture, structure, depth, organic matter, activities of soil organisms, and previous moisture condition. They may also include such surface characteristics as the kind and amount of plant cover (7), litter, size and dispersion of bare soil openings, erosion pavement, slope steepness, and surface disturbances such as trampling by livestock (8).

Inclusion of such site characteristics or treatments may be one of the most important phases of an infiltrometer study. Observations and measurements of surface characteristics usually should be made immediately following installation of the plot unit. At that time, there is no other equipment in place over the plots to impede movements necessary to obtain the desired measurements. Measurements of below-surface characteristics should be delayed until after the test has been completed to avoid the disturbance involved in obtaining them.

CONSTRUCTION SPECIFICATIONS

The Intermountain infiltrometer is not available commercially. It must be custom made. Because of the large number of items made from extruded and sheet aluminum, it is advisable to have the work done by someone familiar with working and welding aluminum. To assist in procurement and assembly of an infiltrometer, all parts with specifications and approximate costs are listed by major units.

Water Supply Unit

Water Development

Two pipes, 8' x 1½" of 1/8" or heavier gage aluminum

One tank, 42" long, 30" wide, 30" deep, of 1/8" aluminum sheet, welded seams, 1" flanged top edges, steel handles each end

If needed for hauling water, one tank, standard round type, 4'6" x 8' capacity 1,000 gals.

Pumping

One pipe strainer, 1½" female threaded, free-flow, Fisher 260 or equal

One suction hose, 6' x 1½", wire reinforced, brass couplings for spanner wrench 1½" male and female

One pump, gasoline-powered, rotary type, brass 1½" male suction and discharge fittings. Recommend pump equal to or better than Pacific Marine Type "Y" or "NY" pumpers. The suitability of various kinds of pumps for infiltrometer work is discussed in some detail by Dortignac (6).

Linen firehose, 1½" in 50' lengths with 1½" brass couplings, mfg.-tested to withstand 300 lbs. square inch pressure. Recommend up to 1,500 feet in rough, dry terrain.

Water Storage

One tank, 60" long, 47" wide, 48" deep, of 1/8" aluminum sheet, welded seams, 1" flanged top edges, steel handles each end, capacity approx. 600 gals.

One tank, 54" long, 36" wide, 48" deep, of 1/8" aluminum sheet, welded seams, 1" flanged top edges, steel handles each end, capacity approx. 400 gals.

Two outlets, 1½" female threaded of steel, welded one to each of above tanks near bottom adjacent corners (see fig. 3).

Siamese Coupling

Two bushings, 1½" male to 3/4" female, steel.

Two 90° street elbows, 3/4" galvanized.

Two close nipples, 6" x 3/4", galvanized.

One union, 3/4", galvanized.

One tee, 3/4", galvanized.

One barrel valve, 3/4" male pipe-threaded inlet, 3/4" male hose threaded outlet, brass.

Gravity Feed

Plastic hose, 3/4" in 100' lengths, 3/4" brass couplings, mfg.-tested to withstand 225 lbs. square inch pressure. Recommend up to 800 feet to provide latitude in operations.

One bushing, 3/4" female hose threaded to 1" male pipe threaded, brass.

One valve, 1" gage type, brass.

Estimated total cost of water supply unit: $1,330.

Pressure Circulation Unit

Operating Reservoir

One milk can, 10-gallon size, galvanized.

Pumping

One pipe strainer, 1½" female threaded, free-flow, Fisher 260 or equal.

One suction hose, 6" x 1½", wire reinforced, brass couplings for spanner wrench, 1½" male and female.

One pump, gasoline-powered, rotary-type, brass 1½" male suction and discharge fittings. Recommend pump equal to or better than Pacific Marine Type "Y" or "NY" pumpers.

Two tarpaulins, 10' x 10', canvas waterproofed.

One reducer, 1½" to 1", female pipe threaded, galvanized.

Two couplings, 1" brass, quick snap-on type, 1" male pipe threaded one end, 1" female hose threaded one end.

Rubber industrial hose, 15' x 1", 1" male hose threaded brass fittings both ends.

Pressure Control

Two valves, 1" gate type, brass.

One 90° street elbow, 1" galvanized.

Two close nipples, 2" x 1", galvanized.

Two tees, 1" galvanized.

One plug, 1" male threaded, brass.

One bushing, 1" female to 1½" male, brass.

Pressure Tank and Accessories

One tank, pressure type, 30" long x 14" diameter, of 1/4" of heavier gage aluminum plate, double welded seams, equipped with sixteen 3/4" pipe threaded female fittings double welded, one 1½" pipe threaded female fitting in one end, four 8" legs of 1½" aluminum alloy tubing, and two steel handles. Should pressure test at 120 lbs. square inch pressure (see fig. 5).

One valve, pressure relief type, 3/4" brass, adjustable from zero to 100 lbs. square inch pressure.

One bushing, 3/4" male to 1/4" female, pipe threaded, steel.

Fourteen barrel valves, 3/4" brass, male pipe threaded inlet, male hose threaded outlet.

One bushing, 1" male pipe threaded to 3/4" female hose threaded, steel.

One pressure gage, brass railroad locomotive type, reading from zero to 70 lbs. square inch pressure, with 1/4" globe valve stem.

One coupling, brass, quick snap-on type, 1/4" male threaded one end, 1/4" female threaded one end.

Fifteen couplings, brass, quick snap-on type, 3/4" male hose threaded one end, 3/4" female hose threaded one end.

Fifteen plastic hoses, 25' x 5/8", with 3/4" brass hose fittings.

Estimated total cost of pressure circulation unit: $810.

Rainfall Applicator Unit

Nozzle Rack

Two channels, 8' long, 4" wide, 2" deep, of 1/4" or heavier gage aluminum plate; tapped for 3/4" pipe threaded bushings at 1-,2-,3-,4-,5-,6-, and 7-foot marks along center line; tapped for 1/4" screws 1/2" from each end on center line; fitted with 1/4" aluminum plate leg supports 4-1/2" x 8" centered on bottom of channel 6" from each end and welded in place (fig. 17).

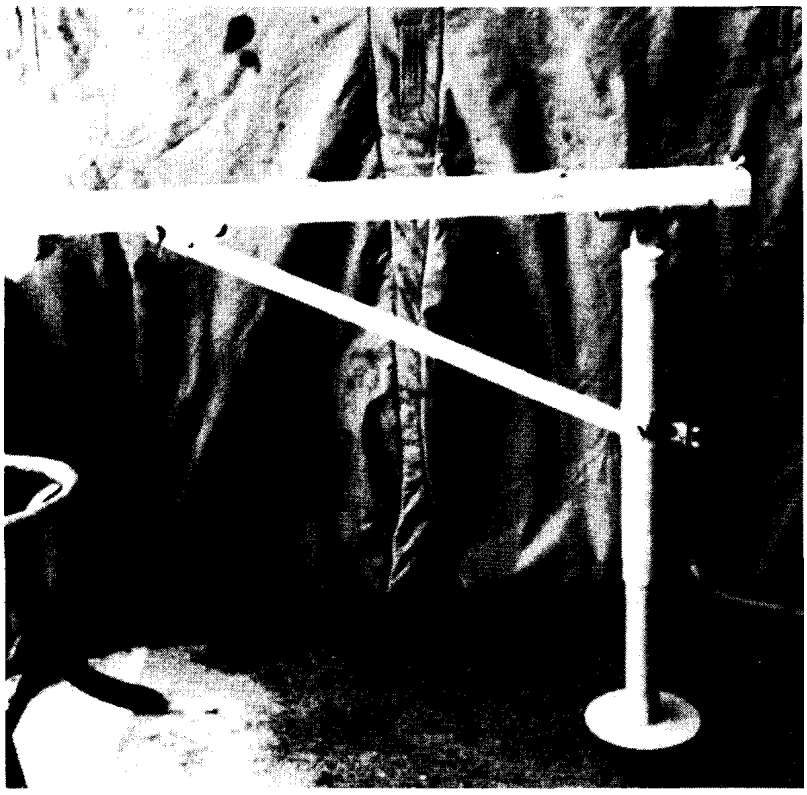


Figure 17.--Detail of rainfall applicator nozzle rack showing bushings for nozzles, tap and wing-nut for spreader bar, and leg assembly.

Two spreader bars, 9'4" x 1" x 1" angle aluminum alloy with 3/4" milled slots at right angles to length 2" from each end to receive 1/4" screws on ends of channels, equipped with corner braces 20" x 1" x 1/8" galvanized strap iron hinged 12" from ends of spreader bars with 1/4" screws and slotted on other ends at right angles to length of braces.

Fourteen bushings, aluminum alloy, 3/4" pipe threaded, seven to each channel screwed into taps.

Fourteen couplings, brass, 3/4" female pipe threaded to 3/4" female hose threaded.

Fourteen couplings, brass, 3/4" quick snap-on type, hose threaded.

Fourteen shower heads, brass, 3/4" ball-and-socket type, pipe threaded.

Fourteen type-F nozzles, details of construction and specifications shown in Figures 18 and 19.

Nozzle Adjuster

One nozzle adjusting level, 5" x 4" of 1/4" blued brass stock with milled nozzle mount beneath level base to fit over 1" diameter nozzle ends; equipped with two adjustable 15-minute bubble levels mounted at right angles, one fixed, the other hinged and adjustable over 17-degree quadrant, locking with set screw. This is a custom-made instrument (see fig. 13).

Sliding Leg

Four sliding legs, of fitted 2" and 1-7/8" aluminum alloy tubing of 1/8" gage, adjustable from 20" to 30" length and locked by 1/4" friction screw and wingnut; equipped with 8" diameter aluminum mud plate of 1/8" gage and 1-7/8" pointed steel spike welded into bottom of leg; equipped with double extruded hinge mount of 1/4" aluminum plate tapped for 1/4" hinge bolt (see fig. 15).

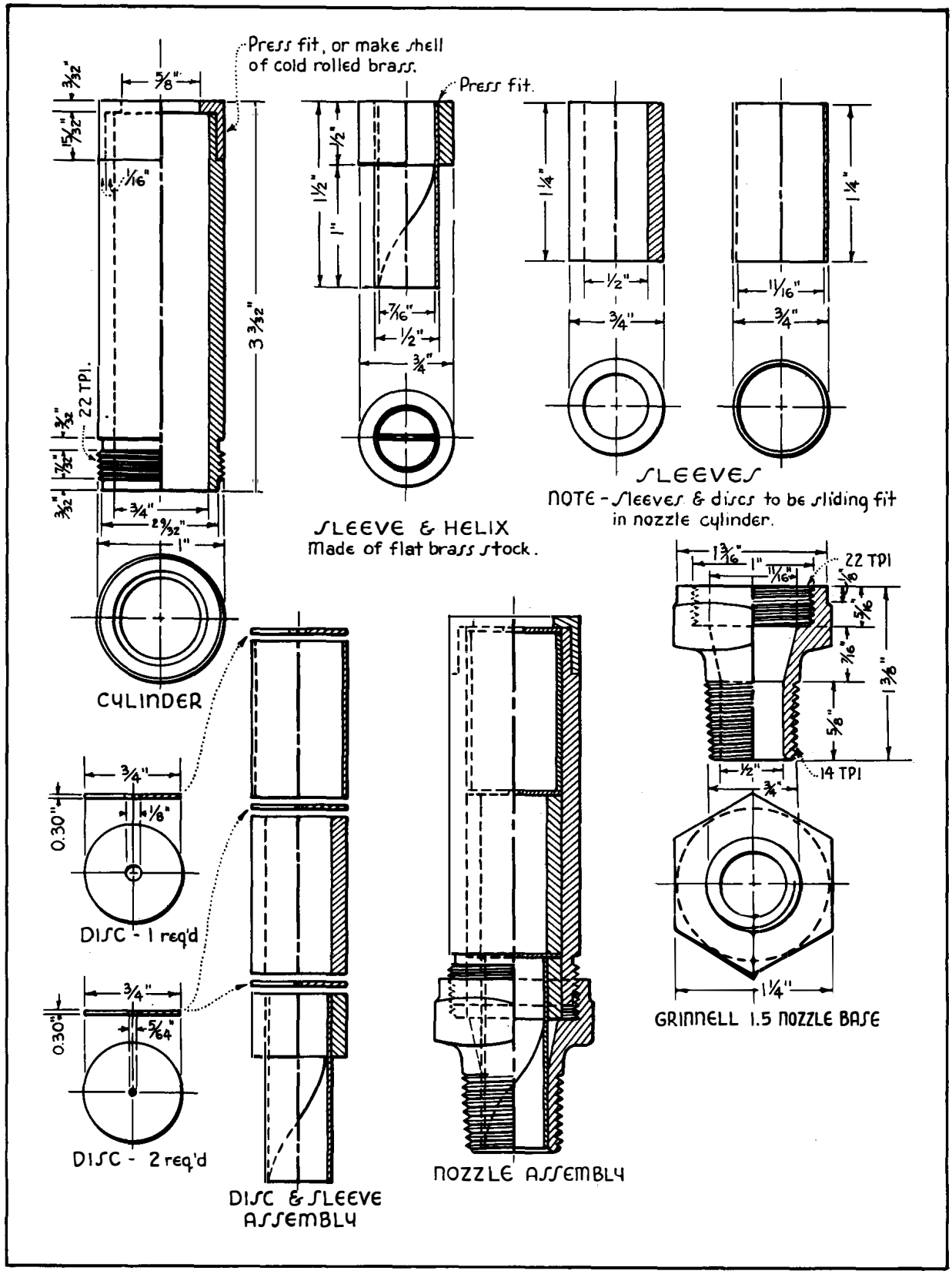
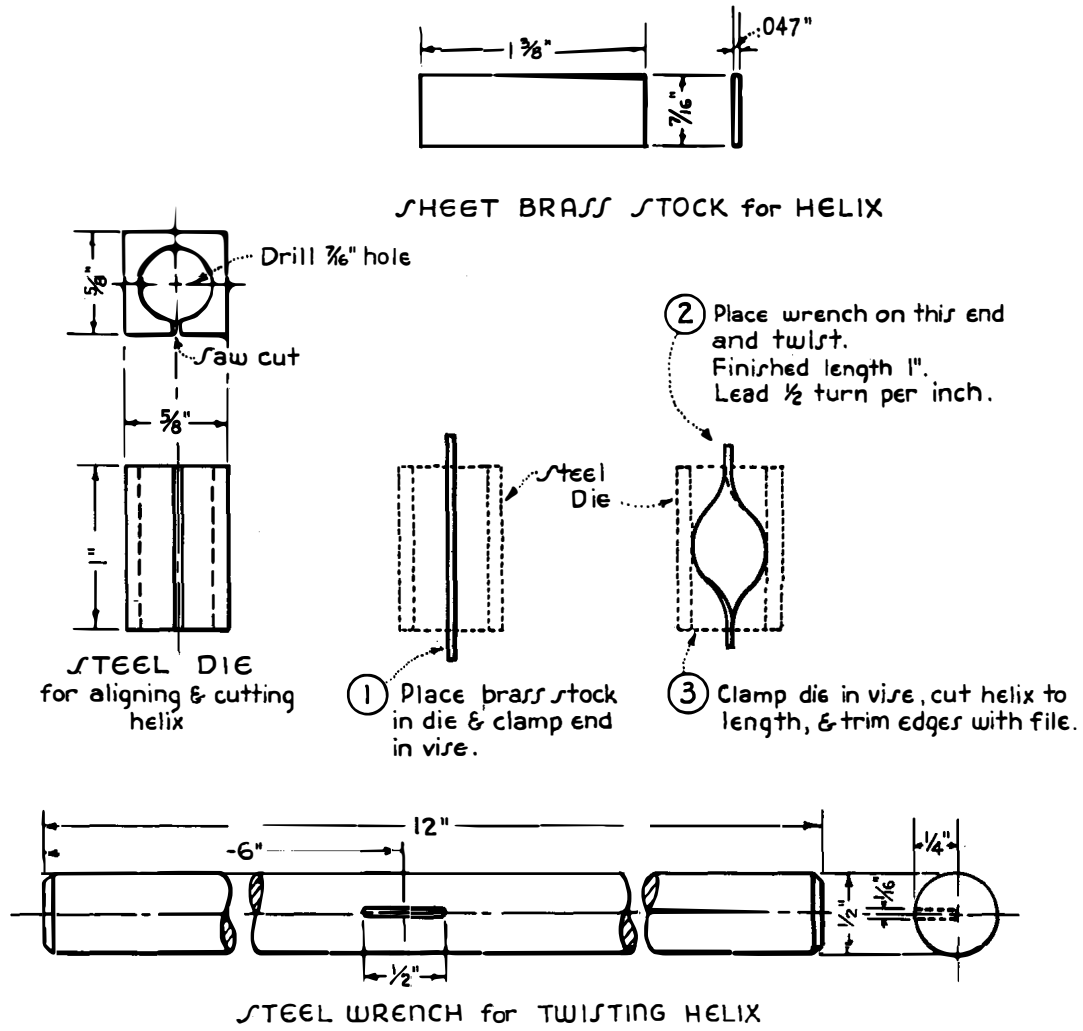


Figure 18.--Construction detail of type-F nozzle.



NOTE : To attach helix in sleeve,
tin both surfaces &
press helix in hot.

Figure 19.--Suggested method for making helix of type-F nozzle.

Four corner braces, 20" x 1" x 1/8" galvanized strap iron, tapped for 1/4" screws 1/2" from each end.

Four corner brace clamps, each of two pieces of 1/8" gage aluminum 4" x 2"; fitted together and tapped for three 1/4" friction screws and wingnuts (see fig. 6).

Eight draw bands, 8" x 1" x 1/16" galvanized strap iron; formed around 2" tubular portion of legs; tapped for 1/4" screws and wingnuts 1/2" from ends.

Thirty-two screws and wingnuts, 1/4" x 1/2" length.

Estimated total cost of rainfall applicator unit: $350.

Plot Unit

Plot Wall

One lower cutoff wall, 7' x 6", of 1/8" sheet steel.

One runoff sill, 6' x 1/2" x 6", of 1/8" sheet steel. Bend to 120-degree angle lengthwise to form 3"-wide spillway and 3"-wide vertical wall. Additional 3" vertical wall of same stock welded on underneath side of spillway to form 1/8"-wide slot for mounting on lower cutoff wall. Spillway notched out to vertical wall at 2' and 4' points and three separate spillways thus formed are separated by 1" x 3" flanges welded on at angle of 60 degrees to vertical wall; 6" x 6" flanges of same stock are welded on upper side of vertical wall at each end and at 2' and 4' points so they extend 3" above upper edge of spillways (see fig. 6).

Four side cutoff walls, 6' x 6", of 1/8" sheet steel. A 6" x 7" piece of same stock with a 6" x 1" x 1/8" separator strip welded on one end to fit over the four upper flanges of runoff sill.

One upper cutoff wall, 7' 1/2" x 6", of 1/8" sheet steel bent at 90° angle at points 6" from either end. A 6" x 6" piece of same stock is welded inside bend to form 6" x 6" x 1/8" slots to fit over upper ends of side walls. At points 2' and 4' from ends, 6' x 6' x 1/8" slots for

inside side walls are formed by welding on four pieces of 6" x 9" x 1/8" sheet bent at 90° angle so that 3" is welding surface on the upper wall and 6" protrudes to form the slots (see fig. 7).

Plot Wall Driver

One plot wall driver, milled from spring steel 5'6" x 6" x 2". A slot 3/16" wide and 3" deep milled down the centerline on the narrow or 2" surface. This slot is widened to 1/2" for 4" on each end to receive flanged ends of cutoff walls. A 1/2" x 3" opening into the slot is milled on one side of the driver at points 21" from each end to fit over inside walls when using driver on upper cutoff wall.

One sledge hammer, either 8- or 12-lb. size.

Estimated cost of each plot unit: $30.

Windbreaker Tent Unit

Tent Frame

Four sliding legs, of fitted 2" x 1/8" x 6' aluminum tubing on outside and 1-7/8" x 1/8" x 5' aluminum tubing on inside. Inside tubing slotted lengthwise between points 6" from either end to receive 1/4" lock screw. Inside tubing forms lower part of leg and is equipped with 1/8" gage aluminum mud plate 8" in diameter and 1-7/8" diameter pointed steel spike in lower end. Outside tubing equipped with either triangular steel brackets or small sleeve brackets of steel at top end and at point 12" from lower end to which horizontal crosspieces are bolted. Outside tubing tapped at point 6" from lower end for 1/4" lock screw (see fig. 9).

Eight horizontal crosspieces, 11' long of 1-7/8" x 1/8" aluminum tubing, tapped near ends for 1/4" bolts for mounting on leg brackets. Four of these crosspieces have brackets similar to those on legs welded at their mid-points to receive two top crosspieces.

Two top crosspieces, 11' long of 1-7/8" x 1/8" aluminum tubing, tapped near ends for 1/4" bolts for mounting on upper horizontal crosspieces. These top crosspieces extend between upper opposite horizontal crosspieces to support top of canvas tent cover.

Four screws, 1/4" x 1", with wingnuts, for locking tent legs at any desired height.

Forty bolts, 1/4" x 2", with wingnuts, for mounting crosspieces on brackets.

Tent Cover

One tent cover, 11-1/2' x 11-1/2' x 9-1/2' high, of 8-ounce awning canvas with double-sewn seams and reinforced corners. Equipped with 12"-wide canvas sod-flap around bottom and 7' vertical opening down center of one side closed either by zipper or tent snaps (tent snaps preferable). Equipped with 12" x 12" openings protected by snap-fastened flaps in center of other three sides. Equipped with heavy web guy rope loops at each top corner and in center of each top edge.

Eight guy ropes, 1/4" x 15', ordinary hemp rope or nylon shock cord.

Eight guy stakes, 3/4" x 3/4" x 18", of angle aluminum, sharpened on one end, and equipped with loose 1/4" x 2" steel rivet near upper end for securing guy rope.

Estimated cost of windbreaker tent unit: $200.

Rainfall Collection and Measuring Unit

Rainfall Collection

Two rain gage troughs, 6' long, 1.8" wide (inside measure), and 3" deep, of 1.8" gage aluminum; welded watertight and adjusted precisely to 1/8" width on open top by five 1/4" x 2" screws through centerline of sides at each 1' point; equipped with 3/4" outlet and 3/4" x 2" hose-threaded nipple on one end

welded flush with inside bottom; equipped with two 1" x 6" bent aluminum brackets at points 1' from each end for mounting on side cutoff walls; tops of sides beveled 45° to sharp inside edge (see fig. 11).

Two collector tubes, 6' long, of 5/8" aluminum tubing with 5/8" plastic hose connection on one end to 3/4" brass hose coupling; other ends joined into single tube by 5/8" aluminum tube Siamese fitting attached with short 5/8" plastic hose sections.

Rainfall Measuring

One calibrated rainfall can, 16.58" diameter, 12" deep, of 1/8" gage aluminum, with lid; equipped with small stilling well or baffle and brackets for holding staff gage.

One staff gage, 1' length graduated in 0.01' markers, of porcelainized steel.

Estimated total cost of rainfall collection and measuring unit: $30.

Runoff and Sediment Collection Unit

Collector Trough

Three collector troughs with lids, of 1/16" gage aluminum sheet, 23" long, 3" deep, 14" from straight upper edge to swedged funnel mouth. Lip along straight upper edge is 1" deep to fit under runoff sill. Funnel 1½" diameter equipped with 1½" aluminum collar 3" from end to divert rain drip from collector cans. Upper edge of lid equipped with 1½" x 23" aluminum strip mounted on three 1/4" lock screws for aligning to lower edge of plot (see fig. 10).

Samples

One sample case, 24" x 21" x 6", of wood construction, compartmentalized for 18 sample jars, with hinged or sliding side and suitcase handle.

Four graduates, standard 100, 250, 500, and 1,000 cc sizes of lucite to avoid breakage.

Six dozen sample jars, standard quart size fruit jars, glass or, if available, preferably lucite containers.

One stopwatch, graduated in seconds.

Total Discharge

Nine milk cans, 10-gallon size with lids, galvanized.

Estimated total cost of runoff and sediment collection unit: $150.

Runoff and Sediment Measuring Unit

Samples

Nine filter funnels, 8" diameter mouths, 1/2" diameter funnel, of galvanized 1/16" sheet steel, welded seam.

Filter paper supply, 10" diameter, medium weight.

One scales, triple-beam type, adjustable, weighs zero to 2,000 grams or more by 0.1 gram increments.

One oven, soil-drying type (if desired in lieu of filtering).

Total Discharge

Nine milk cans, 10-gallon size, with lids, galvanized.

Nine filter funnels, 24" diameter mouths and 1" diameter funnel, 24" high, of galvanized 1/16" sheet steel, welded seam.

Filter paper supply, 21" diameter, medium weight.

One scales, platform type, weighs zero to 200 pounds or more by 1/4-pound increments.

Estimated total cost of runoff and sediment measuring unit: $450.

Accessory Equipment

Calibration Accessories

Thirty-two tin cans, No. 2, galvanized.

One extra rainfall collector can, 16.58" diameter, 12" deep, of 1/8" aluminum sheet.

Sixty square feet of burlap splash dampening material.

Three oilcloths, 7' x 2'6" waterproof.

Pump Accessories

One extra rubber fuel line.

Four extra spark plugs.

Two extra starter ropes.

Two 5-gallon fuel cans, easy-pour spouts.

One drum, steel 15-gallon, with barrel faucet.

One grease gun, Alemite, for regular grease.

One grease gun, Alemite, for water pump grease.

Physical Measurements Accessories

One Abney level, graduated in "percent" scale.

One metallic tape, 100' length.

One tatum, aluminum, 8½ x 11" size.

Tool Kit

One chest, 24" x 20" x 18", wooden construction, hinged lid, two metal handles, compartmentalized as desired for smaller tools and accessories.

One pair grass shears, offset handles.

Three wrenches, Crescent 8", 10", and 12".

Two wrenches, Stiltson pipe, 10" x 14".

Two wrenches, 1½" fire hose spanner type.

One pliers, 6"

One bolt cutter, 10"

One screwdriver, 8"

Two shovels

One pick

Estimated total cost of accessory equipment and tool kit unit: $100.

Estimated total cost of infiltrometer exclusive of transportation: $3,450.

Transport Unit

Two trucks, 1/2-ton capacity, stakeside racks, bed width 4 feet, bed length 6 feet, 4-speed transmission.

or, one truck, 1½-ton capacity, stakeside, bed width 6 feet, bed length 12 feet, dual wheels, 4-speed transmission.

If needed for water hauling, one truck, 1½-ton capacity with mount on bed for water tank, 4-wheel drive preferable.

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